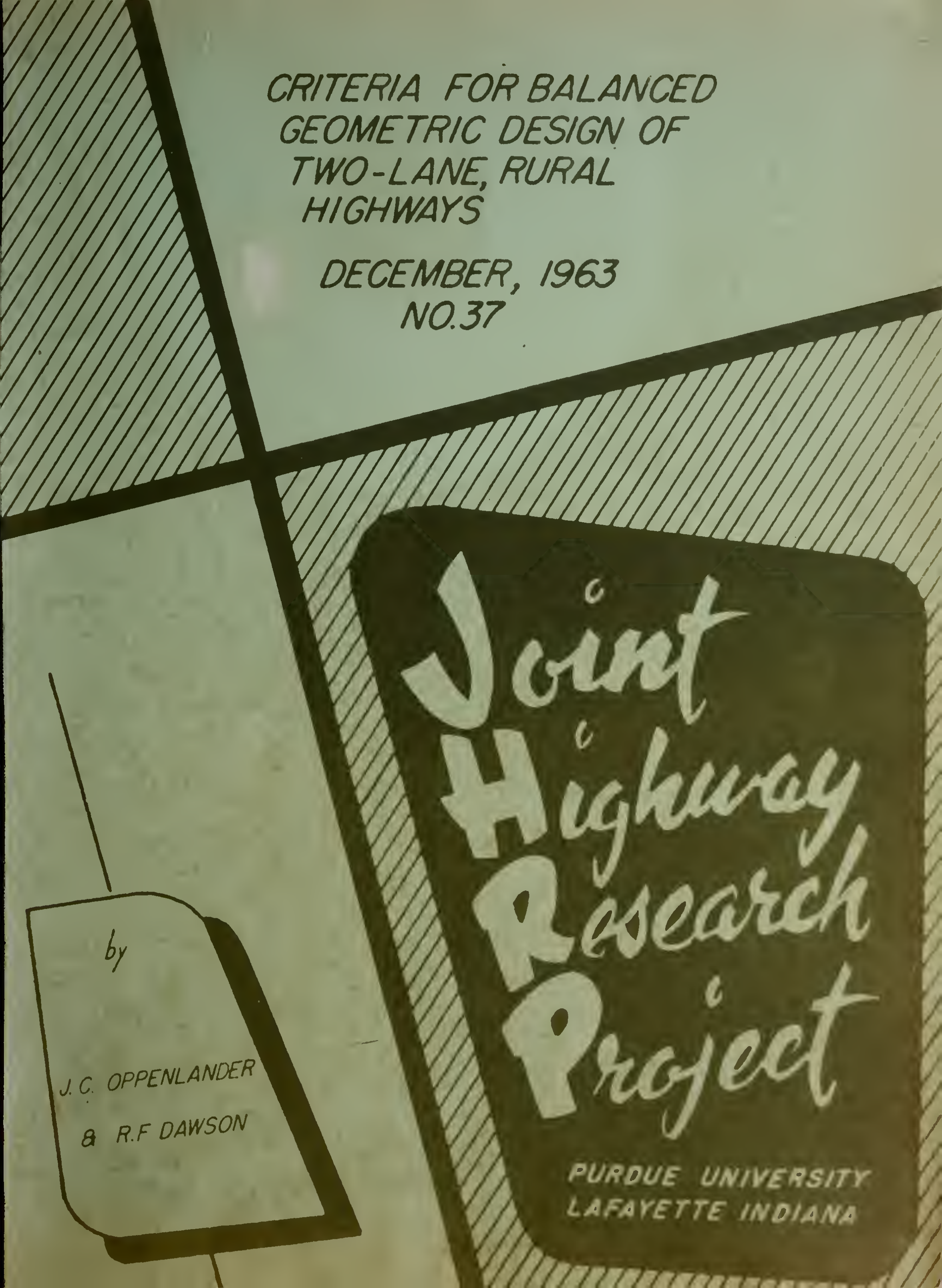

CRITERIA FOR BALANCED GEOMETRIC DESIGN OF TWO-LANE, RURAL HIGHWAYS

DECEMBER, 1963

NO.37

by

J.C. OPPENLANDER

& R.F DAWSON

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

Technical Paper

CRITERIA FOR BALANCED GEOMETRIC DESIGN OF TWO-LANE RURAL HIGHWAYS

TO: K. B. Woods, Director
Joint Highway Research Project

January 7, 1964

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 8-2

Attached is a Technical Paper entitled "Criteria for Balanced Geometric Design of Two-Lane Rural Highways", by J. C. Oppenlander and R. F. Dawson. This paper resulted from a joint effort of the two authors and was not part of the research sponsored by the Project.

This paper is to be presented at the annual meeting of the Highway Research Board in Washington, D. C., in January 1964. The paper is submitted to the Board as information.

Respectfully submitted,

Harold L Michael

Harold L. Michael, Secretary

HLM:bc

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CRITERIA FOR BALANCED GEOMETRIC DESIGN
OF TWO-LANE, RURAL HIGHWAYS

by

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and

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Purdue University
West Lafayette, Indiana

December 1963

CRITERIA FOR BALANCED GEOMETRIC DESIGN OF TWO-LANE, RURAL HIGHWAYS

SYNOPSIS

This investigation was concerned with the development of numerical measures for the significant geometric-design elements of two-lane highways located in rural areas. A mathematical model for the modulus of geometric aspects was solved to evaluate the ease with which vehicular traffic traverses a highway section with a particular combination of geometric features. These geometric moduli are predicated on the approach speed of the traffic and on the speed reduction produced by the design elements.

Solutions to a multiple linear regression equation provided a reasonable estimation of the speed parameters. The geometric-design variables evaluated for two-lane highways were degree of curve, gradient, minimum stopping sight distance, and lane width. In addition, percent of out-of-state cars, percent of truck combinations, number of commercial roadside establishments per mile, and total traffic volume constituted the controls necessary for functional geometric design. The statistical model used for the generation of approach speeds and speed reductions was developed from the multivariate analysis of traffic-flow conditions observed on two-lane, rural highways.

Finally, criteria for different levels of balanced geometric design were developed for use by the design engineer. The moduli for geometric characteristics permit the engineer to select various combinations of

geometric-design elements that produce the same influence on traffic flow. This technique can also be applied to the evaluation of redesign and to the conduct of various highway planning surveys, such as needs studies and sufficiency ratings.

INTRODUCTION

The safe, expedient, and economic movement of traffic is probably most influenced by the geometric aspects of the highway. However, little attention has been devoted to the quantitative evaluation of geometric design. The knowledge of highway geometric design can be fully developed only when the effects of its elements on traffic flow are measured and expressed in numerical terms.

The purposes of this research investigation were to develop numerical ratings of the geometric elements that significantly influence the rate of traffic flow and to establish criteria for the balanced design of two-lane highways located in rural areas. The geometric moduli and the design criteria were predicated on two speed parameters. The average speed on the approach to a particular combination of geometric features indicates the level of the design in regard to efficiency. As average speed increases, the highway section carries the traffic in a more expedient manner. In addition, the speed reduction produced by the given geometric arrangement represents the relative safety of the highway location. Smaller changes in speed are associated with safer highway travel.

These geometric moduli for two-lane, rural highways can be used to:

1. Proportion the geometric-design elements of a highway to achieve a uniform level of traffic-flow conditions;
2. Compare the effects of various combinations of geometric features on the rate of traffic movement;

3. Analyze different geometric designs in regard to their operational characteristics;
4. Evaluate quantitatively the influence of redesign on the behavior of traffic flow;
5. Provide numerical evaluations of tolerable standards for the determination of deficiencies in highway needs studies; and
6. Determine sufficiency ratings for programming highway improvements.

In summary, both practical and theoretical considerations were applied for a scientific approach to the quantitative evaluation of the geometric design of highways. These moduli of geometric aspects provide numerical ratings of various design combinations on an interval scale of measurement. Thus, the engineer can use these moduli for geometric characteristics to assist him in formulating the professional judgment necessary in achieving balanced geometric design.

PROCEDURE

To evaluate the moduli for geometric characteristics, it was necessary to solve a mathematical model for speed conditions that were generated by a statistical model for geometric-design elements and design-control variables. The expressions, "geometric modulus," "modulus of geometric aspects," and "modulus for geometric characteristics," are used interchangeably in this paper to denote the numerical rating of highway geometric design.

Recent theoretical studies of traffic flow have postulated that vehicular movement is produced by a motivating pressure potential. Differences in potential along the highway produce various rates of traffic movement. Therefore, this potential indicates the flow behavior of traffic traveling on a highway section with certain geometric-design characteristics. The formula for the modulus of geometric aspects was presented as:

1. $F_o = \ln (4S_o - 2\Delta S) - \ln \Delta S$

where F_o = geometric modulus,

S_o = average speed on approach to a geometric element, and

ΔS = reduction in average speed produced by the corresponding geometric element.

The derivation of this expression is presented in the literature. (2, 4)* The modulus for geometric characteristics is a numerical measure of the

---

* Numbers in parentheses refer to sources listed in the Bibliography.

ease with which traffic traverses a highway location with certain geometric features.

To solve the preceding equation for real values representing the actual conditions encountered on two-lane highways located in rural areas, a multiple linear regression equation was evaluated for estimating mean approach speeds and speed reductions. The following statistical model was developed from the multivariate analysis of traffic flow on two-lane, rural highways:

$$2.\quad S = 39.34 + 0.0267 X_1 + 0.1396 X_2 - 0.8125 X_3 - 0.1126 X_4 + 0.0007 X_5 + 0.6444 X_6 - 0.5451 X_7 - 0.0082 X_8$$

where S = mean spot speed - mph,

X_1 = out-of-state passenger cars in traffic stream - percent,

X_2 = truck combinations (tractor with one or more trailers) in traffic stream - percent,

X_3 = degree of curve - deg,

X_4 = gradient - percent,

X_5 = minimum stopping sight distance - ft,

X_6 = lane width - ft,

X_7 = number of commercial roadside establishments, such as restaurants, service stations, motels, taverns, etc., per mile (counted on both sides of the roadway for one-half mile in advance of and one-half mile beyond the speed site) - no. per mile, and

X_8 = total traffic volume - vph.

The coefficient of multiple correlation was 0.788 for this investigation and was significant at the 5-percent level. The precision of this

multiple estimate was measured by a standard error of estimate equal to 4.47 mph. This regression model provides a reasonable and efficient evaluation of the functional relationship between mean spot speed and the eight variables that significantly influence the rate of traffic flow on two-lane, rural highways. (3)

The multiple linear regression equation was solved to generate the average speed on the approach to a geometric element (S_o) and the average speed on the corresponding design feature (S_1). The difference between these two mean speeds ($S_o - S_1$) produced the reduction in average speed occasioned by the geometric-design element (ΔS). These two speed parameters (S_o and ΔS) were essential for the solution of the mathematical model representing the modulus for geometric characteristics. This computational technique was programmed in Fortran Language for the IBM 7090 Computer to obtain the geometric moduli for various combinations of geometric elements and design controls.

Design criteria were developed in this investigation for various levels of highway design. Reasonable limiting values of degree of curve, gradient, minimum stopping sight distance, and lane width were formulated from accepted geometric-design policy for design speeds of 30, 40, 50, 60, and 70 mph. (1) The evaluation of the expression for the modulus of geometric aspects permitted the establishment of minimum geometric moduli for the five design speeds.

RESULTS

Solutions to the statistical model were generated for average values of the design-control variables. The four design controls were established at the following levels:

1. Out-of-state passenger cars in traffic stream - 20 percent,
2. Truck combinations in traffic stream - 7.5 percent,
3. Number of commercial roadside establishments per mile - 1 per mile, and
4. Total traffic volume - 900 vph.

These average levels are representative of travel conditions on two-lane, rural highways for design purposes. (1, 3)

GEOMETRIC MODULI

A multivariate analysis of traffic flow indicated that degree of curve, gradient, minimum stopping sight distance, and lane width were the four geometric-design elements that significantly influenced the rate of traffic movement. (3) Therefore, only these four variables were considered over the following ranges in the development of numerical ratings of geometric design:

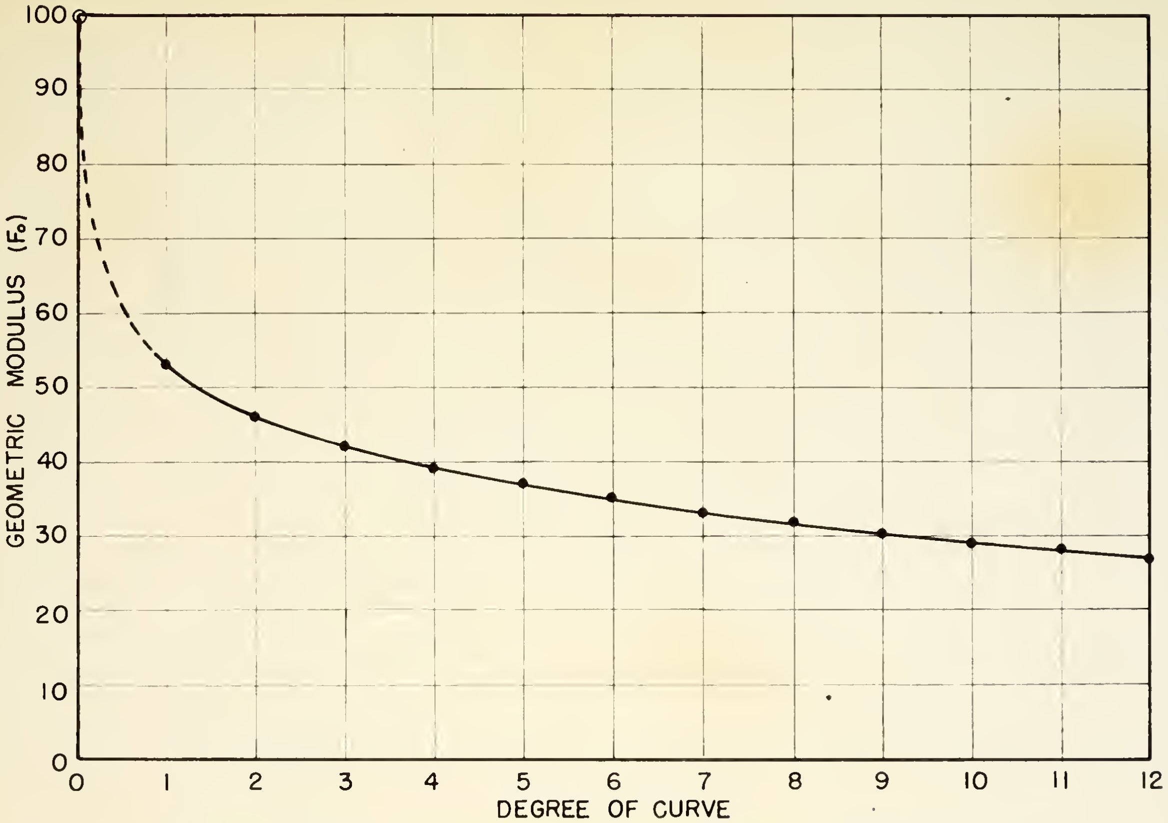
1. Degree of curve - 0 to 12 deg in 1-deg increments,
2. Gradient - 0 to 10 percent in 1-percent increments,
3. Minimum passing sight distance - 200, 300, 400, 500, 600, 800, 1000, 1500, 2000, and 2500 ft, and
4. Lane width - 9, 10, 11, 12, and 13 ft.

These values are fairly indicative of the geometric conditions of two-lane highways located in rural areas. In regard to sight distance, the limit of driver visibility is approximately 2500 ft.

The moduli for geometric characteristics of two-lane, rural highways are presented in the Appendix, Tables 1.00 to 5.10. The geometric moduli calculated from the mathematical model were scaled by a factor of ten to produce the tabled values. Different lane widths and various percent grades are represented, respectively, by the unit digit and the tenth and hundredth digits of the numerical designations of these tables. The selected values of degree of curve and minimum stopping sight distance are listed in each tabulation.

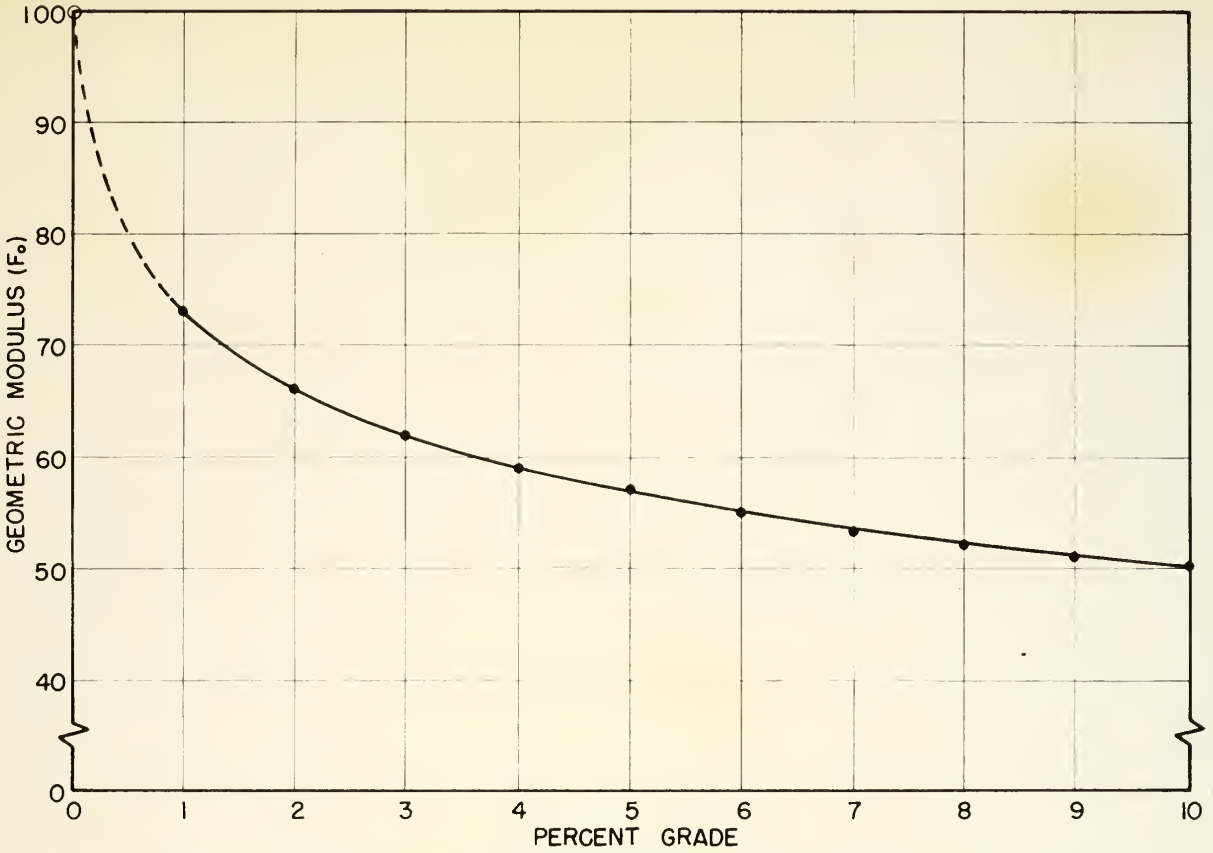
If there is no change in average speed, the calculated value of the geometric modulus becomes infinite. Therefore, in Table 1.00, Appendix, the ideal geometric-design condition of tangent and level alinement with a wide lane and an adequate minimum stopping sight distance was arbitrarily assigned the rating of 100. All remaining geometric moduli were computed in relation to this ideal situation.

The relationships between geometric moduli and each design element are shown in Figs. 1 to 4. Similar effects on the ease of traffic movement are indicated for increasing values of all restrictive variables, although degree of curve has the most pronounced influence. The moduli of geometric aspects rapidly decrease for small restrictive values and continue to decrease at a decreasing rate as the restrictions of the geometric features increase.



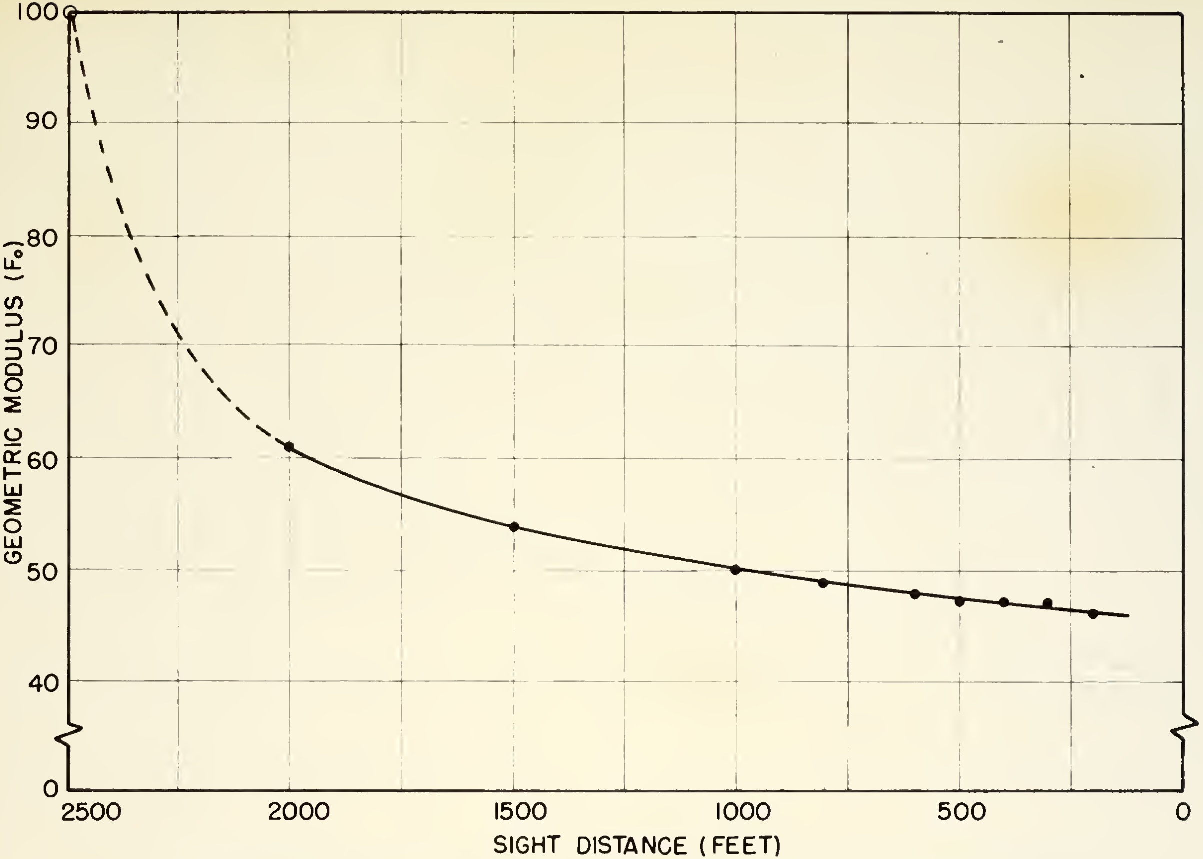
GEOMETRIC MODULI FOR CURVATURE RESTRICTIONS

FIG. 1



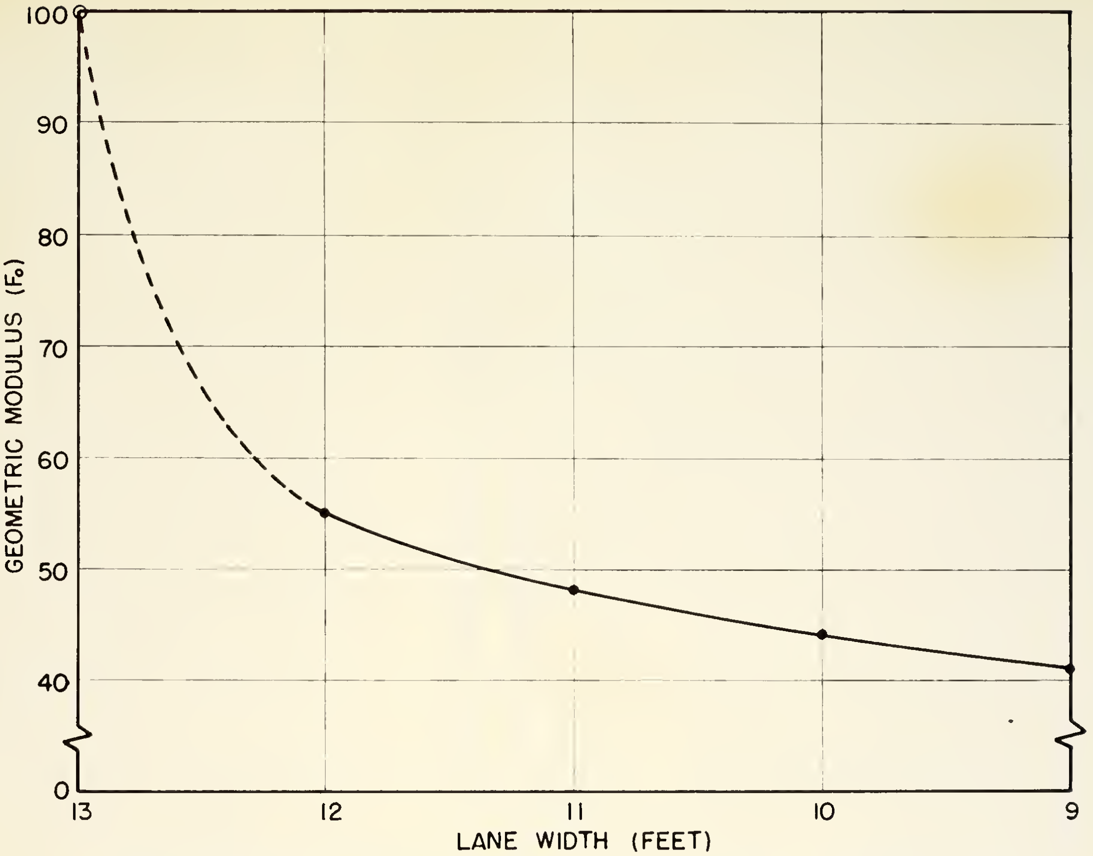
GEOMETRIC MODULI FOR GRADIENT RESTRICTIONS

FIG. 2



GEOMETRIC MODULI FOR SIGHT-DISTANCE RESTRICTIONS

FIG. 3



GEOMETRIC MODULI FOR LANE-WIDTH RESTRICTIONS

FIG. 4

DESIGN CRITERIA

The development of design criteria for two-lane, rural highways is illustrated in Table 1. The tabulated values of the four geometric elements represent reasonable upper limits for degree of curve and gradient and reasonable lower limits for minimum stopping sight distance and lane width at design speeds of 30, 40, 50, 60, and 70 mph. The minimum geometric moduli corresponding to these design speeds are, respectively, 19, 23, 27, 31, and 35. Therefore, in the balanced geometric design of a highway for a given level of design speed, the geometric moduli of the various roadway sections must have ratings equal to or greater than the design-level value.

Design levels of the modulus for geometric characteristics are expressed as a function of design speed in Fig. 5. The straight-line relationship is indicative of modern engineering principles, in that the engineer tends to analyze and synthesize in terms of linear associations.

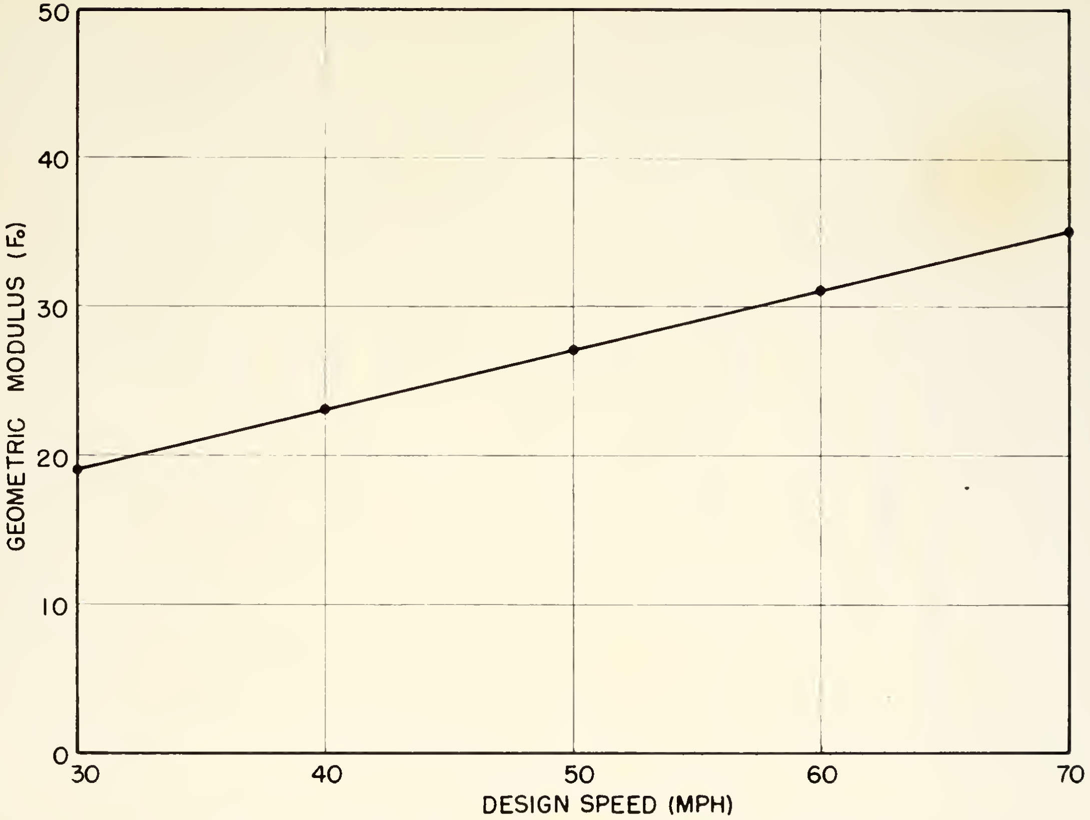
APPLICATIONS

In this section of the report several examples are presented to illustrate the application of geometric moduli to problems in highway planning and design. Although reasonable values of degree of curve, gradient, minimum stopping sight distance, and lane width were selected in the development of minimum criteria for various levels of design and terrain conditions, the practicing engineer can apply design and planning standards that are more applicable to his particular situation.

Table 1

DESIGN CRITERIA FOR TWO-LANE, RURAL HIGHWAYS

Geometric Elements	Design Speed, mph				
	30	40	50	60	70
Degree of Curve, deg	20	12	8	5	3
Gradient, percent	7	6	5	4	3
Min. Stop. Sight Dist., ft	200	300	400	500	600
Lane Width, ft	11	11	11	12	12
Design Level	19	23	27	31	35



GEOMETRIC MODULI FOR DESIGN SPEEDS

FIG. 5

The first illustration is concerned with the design level of the geometric modulus for the selection of various combinations of geometric features to produce a balanced design that is adequate for a specified design speed. If a design speed of 60 mph is warranted, then the moduli of geometric aspects must be equal to or greater than 31 for all sections of this roadway. The limiting conditions of the four geometric elements and the design levels are shown in Table 1 as a function of design speed for two-lane highways located in rural areas.

The modulus for geometric characteristics can also be used to compare the desirability of various combinations of geometric features. To illustrate this second example, it is assumed that two different geometric designs are possible for a given highway section. The degree of curve, gradient, minimum stopping sight distance, and lane width are, respectively, 6 deg, 1 percent, 400 ft, and 12 ft for the first design. The corresponding geometric elements for the second case are 2 deg, 4 percent, 1000 ft, and 12 ft. The respective geometric moduli are determined from Tables 2.01 and 2.04, Appendix, as 31 and 37. Therefore, it is concluded that the second design affords a better combination of geometric features in regard to traffic-flow characteristics.

Another application of the moduli of geometric aspects is to obtain an average numerical rating for the entire length of a highway that is being designed or redesigned. This quantitative evaluation of the operational conditions is readily ascertained by calculating a weighted average of the geometric moduli for the individual sections that comprise the total highway. Each modulus is weighted by the length of highway for which it is the numerical measure. Weighted geometric moduli

can also be used to compare the relative advantages of alternate highway locations.

The final example involves the development of tolerable standards for determining geometric deficiencies in highway needs studies. Estimates of degree of curve, gradient, minimum stopping sight distance, and lane width that permit reasonably safe, efficient, and comfortable travel on two-lane, rural highways are listed in Table 2 for the primary-state classification and in Table 3 for the secondary-state classification. These tolerable standards for level, rolling, and hilly terrain represent levels of geometric conditions that rank below design standards. The tolerable levels of geometric modulus were obtained from Tables 1.00 to 5.10, Appendix, for the specified geometric-design conditions. If the road inventory of a primary-state system shows that a given highway section located in level terrain has a degree of curve, gradient, minimum stopping sight distance, and lane width of 9 deg, 3 percent, 200 ft, and 10 ft, respectively, then the modulus of geometric aspects is determined from Table 4.03, Appendix, as 25. In a comparison of the actual geometric modulus of 25 with the tolerable level of 29 presented in Table 2, it becomes evident that this road section has a geometric deficiency. Thus, numerical ratings of geometric design can be used to evaluate quantitatively the traffic services rendered by existing highway facilities.

Table 2

TOLERABLE CRITERIA FOR TWO-LANE, RURAL HIGHWAYS IN THE PRIMARY-STATE CLASSIFICATION

Geometric Elements	Terrain		
	Level	Rolling	Hilly
Degree of Curve, deg	6	9	12
Gradient, percent	5	6	7
Min. Stop. Sight Dist., ft	500	400	300
Lane Width, ft	11	10	9
Tolerable Level	29	25	22

Table 3

TOLERABLE CRITERIA FOR TWO-LANE, RURAL HIGHWAYS
IN THE SECONDARY-STATE CLASSIFICATION

Geometric Elements	Terrain		
	Level	Rolling	Hilly
Degree of Curve, deg	10	20	30
Gradient, percent	8	10	12
Min. Stop. Sight Dist., ft	400	300	200
Lane Width, ft	10	9	9
Tolerable Level	24	18	13

CONCLUSIONS

In this research investigation moduli for geometric characteristics were developed as numerical evaluations of the significant geometric-design elements applicable to two-lane highways located in rural areas. The geometric modulus quantitatively represents the ease with which traffic traverses a highway section with a particular combination of geometric features. Therefore, the effects of highway geometric design on traffic movement can be measured and expressed in terms of numerical ratings.

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APPENDIX

TABLE 1.00

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 0

DEG.OF	SIGHT DISTANCE -- FEET								
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	100	61	54	50	49	48	47	47	47	46
1	53	49	47	45	44	43	43	42	42	42
2	46	44	42	41	40	40	40	39	39	39
3	42	40	39	38	38	37	37	37	37	37
4	39	38	37	36	36	35	35	35	35	35
5	37	36	35	34	34	34	33	33	33	33
6	35	34	33	32	32	32	32	32	32	32
7	33	32	32	31	31	31	31	30	30	30
8	32	31	30	30	30	29	29	29	29	29
9	30	30	29	29	29	28	28	28	28	28
10	29	29	28	28	28	27	27	27	27	27
11	28	28	27	27	27	26	26	26	26	26
12	27	27	26	26	26	26	26	25	25	25

TABLE 1.01

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 1

DEG.OF	SIGHT DISTANCE -- FEET								
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	73	59	53	49	48	47	47	46	46	45
1	52	48	46	44	43	43	42	42	42	41
2	45	43	42	40	40	39	39	39	39	39
3	41	40	39	38	37	37	37	37	36	36
4	38	37	37	36	35	35	35	35	35	34
5	36	35	35	34	34	33	33	33	33	33
6	34	34	33	32	32	32	32	32	31	31
7	33	32	32	31	31	30	30	30	30	30
8	31	31	30	30	30	29	29	29	29	29
9	30	30	29	29	28	28	28	28	28	28
10	29	28	28	28	27	27	27	27	27	27
11	28	27	27	27	26	26	26	26	26	26
12	27	27	26	26	26	25	25	25	25	25

TABLE 1.02

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 2

DEG.OF	SIGHT DISTANCE -- FEET								
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	66	56	52	48	47	46	46	46	45	45
1	51	48	45	43	43	42	42	42	41	41
2	45	43	41	40	40	39	39	39	38	38
3	41	40	38	37	37	37	37	36	36	36
4	38	37	36	35	35	35	35	34	34	34
5	36	35	34	34	33	33	33	33	33	33
6	34	33	33	32	32	32	32	31	31	31
7	33	32	31	31	31	30	30	30	30	30
8	31	31	30	30	29	29	29	29	29	29
9	30	29	29	28	28	28	28	28	28	28
10	29	28	28	27	27	27	27	27	27	27
11	28	27	27	27	26	26	26	26	26	26
12	27	26	26	26	25	25	25	25	25	25

TABLE 1.03

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 3

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	62	55	51	48	47	46	45	45	44	44
1	49	47	45	43	42	42	41	41	41	41
2	44	42	41	40	39	39	38	38	38	38
3	40	39	38	37	37	36	36	36	36	36
4	38	37	36	35	35	34	34	34	34	34
5	36	35	34	33	33	33	33	33	32	32
6	34	33	33	32	32	31	31	31	31	31
7	32	32	31	31	30	30	30	30	30	30
8	31	30	30	29	29	29	29	29	29	29
9	30	29	29	28	28	28	28	28	28	28
10	29	28	28	27	27	27	27	27	27	27
11	28	27	27	26	26	26	26	26	26	26
12	27	26	26	26	25	25	25	25	25	25

TABLE 1.04

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 4

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	59	53	49	47	46	45	45	44	44	44
1	49	46	44	42	42	41	41	41	40	40
2	43	42	40	39	39	38	38	38	38	38
3	40	39	38	37	36	36	36	36	36	35
4	37	37	36	35	35	34	34	34	34	34
5	35	35	34	33	33	33	33	32	32	32
6	34	33	32	32	31	31	31	31	31	31
7	32	32	31	30	30	30	30	30	30	30
8	31	30	30	29	29	29	29	29	29	28
9	30	29	29	28	28	28	28	28	28	27
10	28	28	28	27	27	27	27	27	27	27
11	27	27	27	26	26	26	26	26	25	26
12	27	26	26	25	25	25	25	25	25	25

TABLE 1.05

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 5

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	57	52	49	46	45	44	44	44	43	43
1	48	45	43	42	41	41	40	40	40	40
2	43	41	40	39	38	38	38	38	37	37
3	40	39	37	37	36	36	35	35	35	35
4	37	36	35	35	34	34	34	34	34	33
5	35	34	34	33	33	32	32	32	32	32
6	33	33	32	32	31	31	31	31	31	31
7	32	31	31	30	30	30	30	30	30	29
8	31	30	30	29	29	29	29	29	28	28
9	29	29	28	28	28	28	28	28	27	27
10	28	28	27	27	27	27	27	27	26	26
11	27	27	27	26	26	25	26	26	26	26
12	26	26	26	25	25	25	25	25	25	25

TABLE 1.06

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 6

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	55	51	48	45	45	44	43	43	43	42
1	47	45	43	41	41	40	40	40	40	39
2	42	41	40	39	38	38	37	37	37	37
3	39	38	37	36	36	36	35	35	35	35
4	37	36	35	34	34	34	34	34	33	33
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10	28	28	27	27	27	27	27	26	26	26
11	27	27	26	26	26	25	26	26	26	25
12	26	26	26	25	25	25	25	25	25	25

TABLE 1.07

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 7

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	53	50	47	45	44	43	43	43	42	42
1	46	44	42	41	40	40	40	39	39	39
2	42	41	39	38	38	37	37	37	37	37
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10	28	28	27	27	27	26	26	26	26	26
11	27	27	26	26	26	26	26	25	25	25
12	26	26	25	25	25	25	25	25	25	25

TABLE 1.08

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 8

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	52	49	46	44	43	43	42	42	42	42
1	45	44	42	41	40	40	39	39	39	39
2	41	40	39	38	37	37	37	37	36	36
3	39	38	37	36	35	35	35	35	35	34
4	36	35	35	34	34	33	33	33	33	33
5	34	34	33	32	32	32	32	32	31	31
6	33	32	32	31	31	31	30	30	30	30
7	31	31	30	30	30	29	29	29	29	29
8	30	30	29	29	28	28	28	28	28	28
9	29	28	28	28	27	27	27	27	27	27
10	28	27	27	27	27	26	26	26	26	26
11	27	27	26	26	26	25	25	25	25	25
12	26	26	25	25	25	25	25	25	24	24

TABLE 1.09
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 9

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	51	48	45	44	43	42	42	42	41	41
1	45	43	41	40	40	39	39	39	38	38
2	41	40	39	38	37	37	37	36	36	36
3	38	37	36	35	35	35	35	34	34	34
4	36	35	34	34	33	33	33	33	33	33
5	34	33	33	32	32	32	32	31	31	31
6	33	32	31	31	31	30	30	30	30	30
7	31	31	30	30	29	29	29	29	29	29
8	30	29	29	28	28	28	28	28	28	28
9	29	28	28	27	27	27	27	27	27	27
10	28	27	27	27	26	26	26	26	26	26
11	27	26	26	26	26	25	25	25	25	25
12	26	26	25	25	25	25	24	24	24	24

TABLE 1.10
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 13 FT. PERCENT GRADE = 10

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	50	47	45	43	42	42	41	41	41	41
1	44	42	41	40	39	39	39	38	38	38
2	41	39	38	37	37	36	36	36	36	36
3	38	37	36	35	35	35	34	34	34	34
4	36	35	34	33	33	33	33	33	33	32
5	34	33	33	32	32	31	31	31	31	31
6	32	32	31	31	30	30	30	30	30	30
7	31	30	30	29	29	29	29	29	29	29
8	30	29	29	28	28	28	28	28	28	28
9	29	28	28	27	27	27	27	27	27	27
10	28	27	27	26	26	26	26	26	26	26
11	27	26	26	26	25	25	25	25	25	25
12	26	25	25	25	25	24	24	24	24	24

TABLE 2.00

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 0

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	55	51	48	46	45	44	44	43	43	43
1	47	45	43	42	41	40	40	40	40	39
2	43	41	40	39	38	38	38	37	37	37
3	39	38	37	36	36	36	35	35	35	35
4	37	36	35	34	34	34	34	34	33	33
5	35	34	33	33	33	32	32	32	32	32
6	33	33	32	31	31	31	31	31	31	30
7	32	31	31	30	30	30	30	30	29	29
8	30	30	29	29	29	29	29	28	28	28
9	29	29	28	28	28	28	27	27	27	27
10	28	28	27	27	27	27	27	26	26	26
11	27	27	26	26	26	25	26	26	26	25
12	26	26	26	25	25	25	25	25	25	25

TABLE 2.01

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 1

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	54	50	47	45	44	43	43	43	42	42
1	46	44	43	41	41	40	40	40	39	39
2	42	41	39	38	38	37	37	37	37	37
3	39	38	37	36	36	35	35	35	35	35
4	37	36	35	34	34	34	33	33	33	33
5	35	34	33	33	32	32	32	32	32	32
6	33	32	32	31	31	31	31	31	30	30
7	32	31	30	30	30	30	29	29	29	29
8	30	30	29	29	29	28	28	28	28	28
9	29	29	28	28	28	27	27	27	27	27
10	28	28	27	27	27	27	26	26	26	26
11	27	27	26	26	26	26	26	25	25	25
12	26	26	25	25	25	25	25	25	25	25

TABLE 2.02

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 2

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	52	49	46	44	44	43	43	42	42	42
1	46	44	42	41	40	40	39	39	39	39
2	42	40	39	38	38	37	37	37	37	36
3	39	38	37	36	35	35	35	35	35	34
4	36	35	35	34	34	33	33	33	33	33
5	34	34	33	32	32	32	32	32	32	31
6	33	32	32	31	31	31	30	30	30	30
7	31	31	30	30	30	29	29	29	29	29
8	30	30	29	29	28	28	28	28	28	28
9	29	29	28	28	27	27	27	27	27	27
10	28	28	27	27	27	26	26	26	26	26
11	27	27	26	26	26	26	25	25	25	25
12	26	26	25	25	25	25	25	25	25	24

TABLE 2.03
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 3

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	51	48	46	44	43	42	42	42	41	41
1	45	43	42	40	40	39	39	39	39	38
2	41	40	39	38	37	37	37	36	36	36
3	38	37	36	35	35	35	35	35	34	34
4	36	35	34	34	33	33	33	33	33	33
5	34	34	33	32	32	32	32	31	31	31
6	33	32	31	31	31	30	30	30	30	30
7	31	31	30	30	29	29	29	29	29	29
8	30	29	29	29	28	28	28	28	28	28
9	29	28	28	28	27	27	27	27	27	27
10	28	27	27	27	26	26	26	26	26	26
11	27	26	26	26	26	25	25	25	25	25
12	26	26	25	25	25	25	25	24	24	24

TABLE 2.04
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 4

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	50	47	45	43	42	42	42	41	41	41
1	44	43	41	40	39	39	39	38	38	38
2	41	39	38	37	37	37	36	36	36	36
3	38	37	36	35	35	35	34	34	34	34
4	36	35	34	34	33	33	33	33	33	32
5	34	33	33	32	32	32	31	31	31	31
6	32	32	31	31	30	30	30	30	30	30
7	31	30	30	29	29	29	29	29	29	29
8	30	29	29	28	28	28	28	28	28	28
9	29	28	28	27	27	27	27	27	27	27
10	28	27	27	26	26	26	26	26	26	26
11	27	26	26	26	25	25	25	25	25	25
12	26	25	25	25	25	24	24	24	24	24

TABLE 2.05
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 5

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	49	46	44	43	42	41	41	41	41	40
1	44	42	41	39	39	39	38	38	38	38
2	40	39	38	37	37	36	36	36	36	36
3	38	37	36	35	35	34	34	34	34	34
4	36	35	34	33	33	33	33	32	32	32
5	34	33	32	32	32	31	31	31	31	31
6	32	32	31	30	30	30	30	30	30	30
7	31	30	30	29	29	29	29	29	29	29
8	30	29	29	28	28	28	28	28	28	28
9	29	28	28	27	27	27	27	27	27	27
10	28	27	27	26	26	26	26	26	26	26
11	27	26	26	25	25	25	25	25	25	25
12	26	25	25	25	25	24	24	24	24	24

TABLE 2.06

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 6

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	48	46	44	42	42	41	41	40	40	40
1	43	42	40	39	39	38	38	38	38	37
2	40	39	38	37	36	36	36	36	35	35
3	37	36	36	35	34	34	34	34	34	34
4	35	34	34	33	33	33	32	32	32	32
5	34	33	32	32	31	31	31	31	31	31
6	32	31	31	30	30	30	30	30	30	30
7	31	30	30	29	29	29	29	29	29	28
8	29	29	29	28	28	28	28	28	27	27
9	28	28	28	27	27	27	27	27	27	26
10	27	27	27	26	26	26	26	26	26	25
11	26	26	26	25	25	25	25	25	25	25
12	26	25	25	25	24	24	24	24	24	24

TABLE 2.07

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 7

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	47	45	43	42	41	41	40	40	40	40
1	43	41	40	39	38	38	38	37	37	37
2	39	38	37	36	36	36	36	35	35	35
3	37	36	35	34	34	34	34	34	33	33
4	35	34	34	33	33	32	32	32	32	32
5	33	33	32	31	31	31	31	31	31	31
6	32	31	31	30	30	30	30	30	29	29
7	31	30	29	29	29	29	29	28	28	28
8	29	29	28	28	28	28	28	27	27	27
9	28	28	27	27	27	27	27	27	26	26
10	27	27	26	26	26	26	26	26	26	25
11	26	26	26	25	25	25	25	25	25	25
12	25	25	25	24	24	24	24	24	24	24

TABLE 2.08

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 8

DEG.OF CURVE	SIGHT DISTANCE - FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	46	44	43	41	41	40	40	40	39	39
1	42	41	39	38	38	38	37	37	37	37
2	39	38	37	36	36	35	35	35	35	35
3	37	36	35	34	34	34	34	33	33	33
4	35	34	33	33	32	32	32	32	32	32
5	33	32	32	31	31	31	31	31	30	30
6	32	31	31	30	30	30	29	29	29	29
7	30	30	29	29	29	28	28	28	28	28
8	29	29	28	28	28	27	27	27	27	27
9	28	28	27	27	27	27	26	26	26	26
10	27	27	26	26	26	26	26	26	25	25
11	26	26	25	25	25	25	25	25	25	25
12	25	25	25	24	24	24	24	24	24	24

TABLE 2.09

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 9

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	46	44	42	41	40	40	39	39	39	39
1	42	40	39	38	38	37	37	37	37	36
2	39	38	37	36	35	35	35	35	35	35
3	36	36	35	34	34	33	33	33	33	33
4	35	34	33	32	32	32	32	32	32	31
5	33	32	32	31	31	31	31	30	30	30
6	31	31	30	30	30	29	29	29	29	29
7	30	30	29	29	29	28	28	28	28	28
8	29	29	28	28	28	27	27	27	27	27
9	28	28	27	27	27	26	26	26	26	26
10	27	27	26	26	26	26	25	25	25	25
11	26	26	25	25	25	25	25	25	25	24
12	25	25	25	24	24	24	24	24	24	24

TABLE 2.10

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 12 FT. PERCENT GRADE = 10

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	45	43	42	40	40	39	39	39	39	38
1	41	40	39	38	37	37	37	37	36	36
2	38	37	36	36	35	35	35	35	34	34
3	36	35	35	34	33	33	33	33	33	33
4	34	34	33	32	32	32	32	32	31	31
5	33	32	31	31	31	30	30	30	30	30
6	31	31	30	30	29	29	29	29	29	29
7	30	30	29	29	28	28	28	28	28	28
8	29	28	28	28	27	27	27	27	27	27
9	28	27	27	27	26	26	26	26	26	26
10	27	26	26	26	26	25	25	25	25	25
11	26	26	25	25	25	25	25	24	24	24
12	25	25	24	24	24	24	24	24	24	24

TABLE 3.00
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 0

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	48	46	44	42	42	41	41	41	40	40
1	43	42	40	39	39	38	38	38	38	37
2	40	39	38	37	36	36	36	36	36	35
3	37	36	36	35	34	34	34	34	34	34
4	35	35	34	33	33	33	32	32	32	32
5	34	33	32	32	31	31	31	31	31	31
6	32	31	31	30	30	30	30	30	30	30
7	31	30	30	29	29	29	29	29	29	28
8	30	29	29	28	28	28	28	28	28	27
9	28	28	28	27	27	27	27	27	27	27
10	27	27	27	26	26	26	26	26	26	26
11	26	26	26	25	25	25	25	25	25	25
12	26	25	25	25	24	24	24	24	24	24

TABLE 3.01
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 1

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	47	45	43	42	41	41	40	40	40	40
1	43	41	40	39	38	38	38	38	37	37
2	40	38	37	36	36	36	36	35	35	35
3	37	36	35	35	34	34	34	34	34	33
4	35	34	34	33	33	32	32	32	32	32
5	33	33	32	31	31	31	31	31	31	31
6	32	31	31	30	30	30	30	30	29	29
7	31	30	30	29	29	29	29	28	28	28
8	29	29	28	28	28	28	28	27	27	27
9	28	28	27	27	27	27	27	27	26	26
10	27	27	26	26	26	26	26	26	26	26
11	26	26	26	25	25	25	25	25	25	25
12	26	25	25	24	24	24	24	24	24	24

TABLE 3.02
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 2

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	47	45	43	41	41	40	40	40	39	39
1	42	41	40	38	38	38	37	37	37	37
2	39	38	37	36	36	35	35	35	35	35
3	37	36	35	34	34	34	34	33	33	33
4	35	34	33	33	32	32	32	32	32	32
5	33	32	32	31	31	31	31	31	31	30
6	32	31	31	30	30	30	30	29	29	29
7	30	30	29	29	29	29	28	28	28	28
8	29	29	28	28	28	28	27	27	27	27
9	28	28	27	27	27	27	26	26	26	26
10	27	27	26	26	26	26	26	26	25	25
11	26	26	26	25	25	25	25	25	25	25
12	25	25	25	24	24	24	24	24	24	24

TABLE 3.03

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 3

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	46	44	42	41	40	40	40	39	39	39
1	42	40	39	38	38	37	37	37	37	37
2	39	38	37	36	36	35	35	35	35	35
3	36	36	35	34	34	34	33	33	33	33
4	35	34	33	32	32	32	32	32	32	32
5	33	32	32	31	31	31	31	30	30	30
6	31	31	30	30	30	29	29	29	29	29
7	30	30	29	29	29	29	28	28	28	28
8	29	29	28	28	28	27	27	27	27	27
9	28	28	27	27	27	26	26	26	26	26
10	27	27	26	26	26	26	26	25	25	25
11	26	26	25	25	25	25	25	25	25	24
12	25	25	25	24	24	24	24	24	24	24

TABLE 3.04

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 4

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	45	43	42	40	40	39	39	39	39	39
1	41	40	39	38	37	37	37	37	36	36
2	38	37	36	36	35	35	35	35	35	34
3	36	35	35	34	34	33	33	33	33	33
4	34	34	33	32	32	32	32	32	31	31
5	33	32	31	31	31	30	30	30	30	30
6	31	31	30	30	30	29	29	29	29	29
7	30	30	29	29	28	28	28	28	28	28
8	29	28	28	28	27	27	27	27	27	27
9	28	27	27	27	26	26	26	26	26	26
10	27	27	26	26	26	25	25	25	25	25
11	26	26	25	25	25	25	25	25	24	24
12	25	25	24	24	24	24	24	24	24	24

TABLE 3.05

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 5

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	45	43	41	40	40	39	39	39	38	38
1	41	40	38	37	37	37	36	36	36	36
2	38	37	36	35	35	35	35	34	34	34
3	36	35	34	34	33	33	33	33	33	33
4	34	33	33	32	32	32	31	31	31	31
5	33	32	31	31	31	30	30	30	30	30
6	31	31	30	30	29	29	29	29	29	29
7	30	29	29	28	28	28	28	28	28	28
8	29	28	28	27	27	27	27	27	27	27
9	28	27	27	27	26	26	26	26	26	26
10	27	26	26	26	25	25	25	25	25	25
11	26	26	25	25	25	25	24	24	24	24
12	25	25	24	24	24	24	24	24	24	24

TABLE 3.06

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 6

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	44	42	41	40	39	39	38	38	38	38
1	40	39	38	37	37	36	36	36	36	36
2	38	37	36	35	35	34	34	34	34	34
3	36	35	34	33	33	33	33	33	32	32
4	34	33	33	32	32	31	31	31	31	31
5	32	32	31	31	30	30	30	30	30	30
6	31	30	30	29	29	29	29	29	29	29
7	30	29	29	28	28	28	28	28	28	28
8	29	28	28	27	27	27	27	27	27	27
9	28	27	27	26	26	26	26	26	26	26
10	27	26	26	26	25	25	25	25	25	25
11	26	25	25	25	25	24	24	24	24	24
12	25	25	24	24	24	24	24	24	23	23

TABLE 3.07

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 7

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	43	42	40	39	39	38	38	38	38	38
1	40	39	38	37	36	36	36	36	36	35
2	37	37	36	35	35	34	34	34	34	34
3	35	35	34	33	33	33	33	32	32	32
4	34	33	32	32	31	31	31	31	31	31
5	32	32	31	30	30	30	30	30	30	30
6	31	30	30	29	29	29	29	29	29	28
7	30	29	29	28	28	28	28	28	28	27
8	28	28	28	27	27	27	27	27	27	27
9	27	27	27	26	26	26	26	26	26	26
10	27	26	26	25	25	25	25	25	25	25
11	26	25	25	25	24	24	24	24	24	24
12	25	24	24	24	24	24	24	23	23	23

TABLE 3.08

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 8

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	43	41	40	39	38	38	38	38	37	37
1	40	39	37	37	36	36	36	35	35	35
2	37	36	35	35	34	34	34	34	34	33
3	35	34	34	33	33	32	32	32	32	32
4	33	33	32	32	31	31	31	31	31	31
5	32	31	31	30	30	30	30	30	30	29
6	31	30	30	29	29	29	29	29	28	28
7	29	29	28	28	28	28	28	28	27	27
8	28	28	27	27	27	27	27	27	26	26
9	27	27	27	26	26	26	26	26	26	26
10	26	26	26	25	25	25	25	25	25	25
11	26	25	25	24	24	24	24	24	24	24
12	25	24	24	24	24	23	23	23	23	23

TABLE 3.09

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 9

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	42	41	40	39	38	38	37	37	37	37
1	39	38	37	36	36	36	35	35	35	35
2	37	36	35	34	34	34	34	33	33	33
3	35	34	33	33	32	32	32	32	32	32
4	33	33	32	31	31	31	31	31	31	30
5	32	31	31	30	30	30	30	29	29	29
6	30	30	29	29	29	29	28	28	28	28
7	29	29	28	28	28	28	27	27	27	27
8	28	28	27	27	27	27	27	26	26	26
9	27	27	26	26	26	26	26	26	25	25
10	26	26	26	25	25	25	25	25	25	25
11	25	25	25	24	24	24	24	24	24	24
12	25	24	24	24	24	23	23	23	23	23

TABLE 3.10

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 11 FT. PERCENT GRADE = 10

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	42	41	39	38	38	37	37	37	37	37
1	39	38	37	36	36	35	35	35	35	35
2	37	36	35	34	34	34	33	33	33	33
3	35	34	33	33	32	32	32	32	32	32
4	33	32	32	31	31	31	31	30	30	30
5	32	31	30	30	30	30	29	29	29	29
6	30	30	29	29	29	28	28	28	28	28
7	29	29	28	28	28	27	27	27	27	27
8	28	28	27	27	27	26	26	26	26	26
9	27	27	26	26	26	26	25	25	25	25
10	26	26	25	25	25	25	25	25	25	25
11	25	25	25	24	24	24	24	24	24	24
12	24	24	24	24	23	23	23	23	23	23

TABLE 4.00

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 0

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	44	42	41	40	39	39	39	38	38	38
1	41	39	38	37	37	36	36	36	36	36
2	38	37	36	35	35	35	34	34	34	34
3	36	35	34	33	33	33	33	33	33	32
4	34	33	33	32	32	31	31	31	31	31
5	32	32	31	31	30	30	30	30	30	30
6	31	30	30	29	29	29	29	29	29	29
7	30	29	29	28	28	28	28	28	28	28
8	29	28	28	27	27	27	27	27	27	27
9	28	27	27	26	26	26	26	26	26	26
10	27	26	26	26	25	25	25	25	25	25
11	26	25	25	25	25	24	24	24	24	24
12	25	25	24	24	24	24	24	24	24	23

TABLE 4.01

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 1

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	44	42	41	39	39	38	38	38	38	38
1	40	39	38	37	37	36	36	36	36	36
2	38	37	36	35	35	34	34	34	34	34
3	35	35	34	33	33	33	33	32	32	32
4	34	33	32	32	32	31	31	31	31	31
5	32	32	31	30	30	30	30	30	30	30
6	31	30	30	29	29	29	29	29	29	29
7	30	29	29	28	28	28	28	28	28	28
8	29	28	28	27	27	27	27	27	27	27
9	27	27	27	26	26	26	26	26	26	26
10	27	26	26	25	25	25	25	25	25	25
11	26	25	25	25	24	24	24	24	24	24
12	25	25	24	24	24	24	24	23	23	23

TABLE 4.02

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 2

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	43	42	40	39	39	38	38	38	37	37
1	40	39	38	37	36	35	36	36	35	35
2	37	36	35	35	34	34	34	34	34	34
3	35	34	34	33	33	32	32	32	32	32
4	33	33	32	32	31	31	31	31	31	31
5	32	31	31	30	30	30	30	30	30	29
6	31	30	30	29	29	29	29	29	28	28
7	29	29	29	28	28	28	28	28	27	27
8	28	28	27	27	27	27	27	27	27	26
9	27	27	27	26	26	26	26	26	26	26
10	26	26	26	25	25	25	25	25	25	25
11	26	25	25	25	24	24	24	24	24	24
12	25	24	24	24	24	24	23	23	23	23

TABLE 4.03

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 3

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	43	41	40	39	38	38	38	37	37	37
1	39	38	37	36	36	36	35	35	35	35
2	37	36	35	34	34	34	34	34	33	33
3	35	34	33	33	33	32	32	32	32	32
4	33	33	32	31	31	31	31	31	31	30
5	32	31	31	30	30	30	30	30	29	29
6	30	30	29	29	29	29	29	28	28	28
7	29	29	28	28	28	28	27	27	27	27
8	28	28	27	27	27	27	27	26	26	26
9	27	27	26	26	26	26	26	26	26	25
10	26	26	26	25	25	25	25	25	25	25
11	25	25	25	24	24	24	24	24	24	24
12	25	24	24	24	24	23	23	23	23	23

TABLE 4.04

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 4

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	42	41	39	38	38	37	37	37	37	37
1	39	38	37	36	36	35	35	35	35	35
2	37	36	35	34	34	34	33	33	33	33
3	35	34	33	33	32	32	32	32	32	32
4	33	32	32	31	31	31	31	31	30	30
5	32	31	30	30	30	30	29	29	29	29
6	30	30	29	29	29	28	28	28	28	28
7	29	29	28	28	28	27	27	27	27	27
8	28	28	27	27	27	27	26	26	26	26
9	27	27	26	26	26	26	26	25	25	25
10	26	26	25	25	25	25	25	25	25	25
11	25	25	25	24	24	24	24	24	24	24
12	25	24	24	24	23	23	23	23	23	23

TABLE 4.05

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 5

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	42	40	39	38	38	37	37	37	37	36
1	39	38	37	36	35	35	35	35	35	34
2	36	35	35	34	34	33	33	33	33	33
3	34	34	33	32	32	32	32	32	32	31
4	33	32	32	31	31	31	30	30	30	30
5	31	31	30	30	30	29	29	29	29	29
6	30	30	29	29	28	28	28	28	28	28
7	29	29	28	28	27	27	27	27	27	27
8	28	28	27	27	27	26	26	26	26	26
9	27	27	26	26	26	26	25	25	25	25
10	26	26	25	25	25	25	25	25	25	24
11	25	25	25	24	24	24	24	24	24	24
12	24	24	24	23	23	23	23	23	23	23

TABLE 4.06

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 6

SIGHT DISTANCE -- FEET

DEG.OF CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	41	40	39	38	37	37	37	36	36	36
1	38	37	36	35	35	35	35	35	34	34
2	36	35	34	34	33	33	33	33	33	33
3	34	33	33	32	32	32	32	31	31	31
4	33	32	31	31	31	30	30	30	30	30
5	31	31	30	30	29	29	29	29	29	29
6	30	29	29	29	28	28	28	28	28	28
7	29	28	28	28	27	27	27	27	27	27
8	28	27	27	27	26	26	26	25	26	26
9	27	26	26	26	26	25	25	25	25	25
10	26	26	25	25	25	25	25	24	24	24
11	25	25	24	24	24	24	24	24	24	24
12	24	24	24	23	23	23	23	23	23	23

TABLE 4.07

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 7

SIGHT DISTANCE -- FEET

DEG.OF CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	41	39	38	37	37	37	36	36	36	36
1	38	37	36	35	35	35	34	34	34	34
2	36	35	34	33	33	33	33	33	33	32
3	34	33	33	32	32	32	31	31	31	31
4	32	32	31	31	30	30	30	30	30	30
5	31	30	30	29	29	29	29	29	29	29
6	30	29	29	28	28	28	28	28	28	28
7	29	28	28	27	27	27	27	27	27	27
8	28	27	27	26	26	26	26	26	26	26
9	27	26	26	26	25	25	25	25	25	25
10	26	25	25	25	25	24	24	24	24	24
11	25	25	24	24	24	24	24	24	24	23
12	24	24	24	23	23	23	23	23	23	23

TABLE 4.08

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 8

SIGHT DISTANCE -- FEET

DEG.OF CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	40	39	38	37	37	36	36	36	36	36
1	38	37	36	35	35	34	34	34	34	34
2	36	35	34	33	33	33	33	32	32	32
3	34	33	32	32	32	31	31	31	31	31
4	32	32	31	30	30	30	30	30	30	30
5	31	30	30	29	29	29	29	29	29	29
6	30	29	29	28	28	28	28	28	28	28
7	29	26	28	27	27	27	27	27	27	27
8	28	27	27	26	26	26	26	26	26	26
9	27	26	26	25	25	25	25	25	25	25
10	26	25	25	25	25	24	24	24	24	24
11	25	25	24	24	24	24	24	24	23	23
12	24	24	23	23	23	23	23	23	23	23

TABLE 4.09

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 9

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	40	39	38	37	36	36	36	36	35	35
1	37	36	36	35	34	34	34	34	34	34
2	35	34	34	33	33	33	32	32	32	32
3	34	33	32	32	31	31	31	31	31	31
4	32	31	31	30	30	30	30	30	30	30
5	31	30	30	29	29	29	29	29	29	28
6	29	29	29	28	28	28	28	28	27	27
7	28	28	28	27	27	27	27	27	27	26
8	27	27	27	26	26	26	26	26	26	26
9	26	26	26	25	25	25	25	25	25	25
10	26	25	25	25	24	24	24	24	24	24
11	25	24	24	24	24	24	23	23	23	23
12	24	24	23	23	23	23	23	23	23	23

TABLE 4.10

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 10 FT. PERCENT GRADE = 10

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	39	38	37	36	36	36	36	35	35	35
1	37	36	35	34	34	34	34	34	33	33
2	35	34	34	33	33	32	32	32	32	32
3	33	33	32	31	31	31	31	31	31	31
4	32	31	31	30	30	30	30	30	29	29
5	31	30	29	29	29	29	29	28	28	28
6	29	29	28	28	28	28	28	27	27	27
7	28	28	27	27	27	27	27	27	26	26
8	27	27	26	26	26	26	26	26	26	25
9	26	26	26	25	25	25	25	25	25	25
10	25	25	25	24	24	24	24	24	24	24
11	25	24	24	24	24	23	23	23	23	23
12	24	24	23	23	23	23	23	23	23	22

TABLE 5.00

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT.   PERCENT GRADE = 0

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	41	40	39	38	37	37	37	37	36	36
1	38	37	36	36	35	35	35	35	34	34
2	36	35	35	34	34	33	33	33	33	33
3	34	34	33	32	32	32	32	32	31	31
4	33	32	31	31	31	30	30	30	30	30
5	31	31	30	30	29	29	29	29	29	29
6	30	30	29	29	28	28	28	28	28	28
7	29	28	28	28	27	27	27	27	27	27
8	28	27	27	27	26	26	26	26	26	26
9	27	26	26	26	26	25	25	25	25	25
10	26	26	25	25	25	25	25	24	24	24
11	25	25	24	24	24	24	24	24	24	24
12	24	24	24	23	23	23	23	23	23	23

TABLE 5.01

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT.   PERCENT GRADE = 1

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	41	40	38	37	37	37	36	36	36	36
1	38	37	36	35	35	35	35	34	34	34
2	36	35	34	34	33	33	33	33	33	32
3	34	33	33	32	32	32	31	31	31	31
4	32	32	31	31	30	30	30	30	30	30
5	31	31	30	30	29	29	29	29	29	29
6	30	29	29	28	28	28	28	28	28	28
7	29	28	28	27	27	27	27	27	27	27
8	28	27	27	26	26	26	26	26	26	26
9	27	26	26	26	25	25	25	25	25	25
10	26	25	25	25	25	25	24	24	24	24
11	25	25	24	24	24	24	24	24	24	24
12	24	24	24	23	23	23	23	23	23	23

TABLE 5.02

MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT.   PERCENT GRADE = 2

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	40	39	38	37	37	36	36	36	36	36
1	38	37	36	35	35	34	34	34	34	34
2	36	35	34	33	33	33	33	33	32	32
3	34	33	32	32	32	31	31	31	31	31
4	32	32	31	31	30	30	30	30	30	30
5	31	30	30	29	29	29	29	29	29	29
6	30	29	29	28	28	28	28	28	28	28
7	29	28	28	27	27	27	27	27	27	27
8	28	27	27	26	26	26	26	26	26	26
9	27	26	26	25	25	25	25	25	25	25
10	26	25	25	25	25	24	24	24	24	24
11	25	25	24	24	24	24	24	24	23	23
12	24	24	23	23	23	23	23	23	23	23

TABLE 5.03
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 3

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	40	39	38	37	36	36	36	36	36	35
1	37	36	36	35	34	34	34	34	34	34
2	35	35	34	33	33	33	32	32	32	32
3	34	33	32	32	31	31	31	31	31	31
4	32	31	31	30	30	30	30	30	30	30
5	31	30	30	29	29	29	29	29	29	28
6	30	29	29	28	28	28	28	28	28	27
7	28	28	28	27	27	27	27	27	27	27
8	27	27	27	26	26	26	26	26	26	26
9	26	26	26	25	25	25	25	25	25	25
10	26	25	25	25	24	24	24	24	24	24
11	25	24	24	24	24	24	23	23	23	23
12	24	24	23	23	23	23	23	23	23	23

TABLE 5.04
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 4

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	40	38	37	36	36	36	36	35	35	35
1	37	36	35	35	34	34	34	34	34	33
2	35	34	34	33	33	32	32	32	32	32
3	33	33	32	31	31	31	31	31	31	31
4	32	31	31	30	30	30	30	30	29	29
5	31	30	30	29	29	29	29	28	28	28
6	29	29	28	28	28	28	28	27	27	27
7	28	28	27	27	27	27	27	27	26	26
8	27	27	26	26	26	26	26	26	26	26
9	26	26	26	25	25	25	25	25	25	25
10	26	25	25	24	24	24	24	24	24	24
11	25	24	24	24	24	23	23	23	23	23
12	24	24	23	23	23	23	23	23	23	23

TABLE 5.05
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 5

DEG.OF CURVE	SIGHT DISTANCE -- FEET 2500	2000	1500	1000	800	600	500	400	300	200
0	39	38	37	36	36	35	35	35	35	35
1	37	36	35	34	34	34	34	33	33	33
2	35	34	33	33	32	32	32	32	32	32
3	33	32	32	31	31	31	31	31	31	30
4	32	31	31	30	30	30	30	29	29	29
5	30	30	29	29	29	29	28	28	28	28
6	29	29	28	28	28	28	27	27	27	27
7	28	28	27	27	27	27	26	26	26	26
8	27	27	26	26	26	26	26	26	25	25
9	26	26	26	25	25	25	25	25	25	25
10	25	25	25	24	24	24	24	24	24	24
11	25	24	24	24	23	23	23	23	23	23
12	24	24	23	23	23	23	23	23	22	22

TABLE 5.06
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 6

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	39	38	37	36	36	35	35	35	35	35
1	36	36	35	34	34	34	33	33	33	33
2	35	34	33	32	32	32	32	32	32	32
3	33	32	32	31	31	31	31	30	30	30
4	31	31	30	30	30	29	29	29	29	29
5	30	30	29	29	29	28	28	28	28	28
6	29	29	28	28	28	27	27	27	27	27
7	28	28	27	27	27	26	26	26	26	26
8	27	27	26	26	26	26	26	25	25	25
9	26	26	25	25	25	25	25	25	25	24
10	25	25	25	24	24	24	24	24	24	24
11	24	24	24	24	23	23	23	23	23	23
12	24	23	23	23	23	23	23	22	22	22

TABLE 5.07
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 7

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	38	37	36	36	35	35	35	35	35	34
1	36	35	35	34	34	33	33	33	33	33
2	34	34	33	32	32	32	32	32	31	31
3	33	32	31	31	31	30	30	30	30	30
4	31	31	30	30	30	29	29	29	29	29
5	30	30	29	29	28	28	28	28	28	28
6	29	28	28	28	27	27	27	27	27	27
7	28	27	27	27	26	26	26	26	26	26
8	27	27	26	26	26	25	25	25	25	25
9	26	26	25	25	25	25	25	25	24	24
10	25	25	24	24	24	24	24	24	24	24
11	24	24	24	23	23	23	23	23	23	23
12	24	23	23	23	23	22	22	22	22	22

TABLE 5.08
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 8

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	38	37	36	35	35	35	35	34	34	34
1	36	35	34	34	33	33	33	33	33	33
2	34	33	33	32	32	32	31	31	31	31
3	33	32	31	31	31	30	30	30	30	30
4	31	31	30	30	29	29	29	29	29	29
5	30	29	29	28	28	28	28	28	28	28
6	29	28	28	27	27	27	27	27	27	27
7	28	27	27	27	26	26	26	26	26	26
8	27	26	26	26	25	25	25	25	25	25
9	26	26	25	25	25	25	24	24	24	24
10	25	25	24	24	24	24	24	24	24	24
11	24	24	24	23	23	23	23	23	23	23
12	24	23	23	23	22	22	22	22	22	22

TABLE 5.09
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 9

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	38	37	36	35	35	34	34	34	34	34
1.	36	35	34	33	33	33	33	33	32	32
2	34	33	33	32	32	31	31	31	31	31
3	32	32	31	31	30	30	30	30	30	30
4	31	30	30	29	29	29	29	29	29	29
5	30	29	29	28	28	28	28	28	28	28
6	29	28	28	27	27	27	27	27	27	27
7	28	27	27	26	26	26	26	26	26	26
8	27	26	26	26	25	25	25	25	25	25
9	26	25	25	25	25	24	24	24	24	24
10	25	25	24	24	24	24	24	24	23	23
11	24	24	24	23	23	23	23	23	23	23
12	23	23	23	23	22	22	22	22	22	22

TABLE 5.10
MODULI FOR GEOMETRIC CHARACTERISTICS

LANE WIDTH = 9 FT. PERCENT GRADE = 10

DEG.OF	SIGHT DISTANCE -- FEET									
CURVE	2500	2000	1500	1000	800	600	500	400	300	200
0	37	37	36	35	35	34	34	34	34	34
1	35	35	34	33	33	33	33	32	32	32
2	34	33	32	32	31	31	31	31	31	31
3	32	32	31	30	30	30	30	30	30	30
4	31	30	30	29	29	29	29	29	29	28
5	30	29	29	28	28	28	28	28	28	27
6	28	28	28	27	27	27	27	27	27	27
7	27	27	27	26	26	26	26	26	26	26
8	27	26	26	25	25	25	25	25	25	25
9	26	25	25	25	24	24	24	24	24	24
10	25	24	24	24	24	24	24	23	23	23
11	24	24	23	23	23	23	23	23	23	23
12	23	23	23	22	22	22	22	22	22	22